There's a Good Explanation for the Recent Big Snowfalls Across North Central and Northeast Colorado

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After a dry and relatively warm start to March along the Colorado Front Range,

conditions turned snowy and colder with a significant shift in the jet stream/storm track over the western continental United States.

Monthly Snow Totals for Several Official NWS Observing Stations in North Central and Northeast Colorado for the 2012-2013 Snow Season

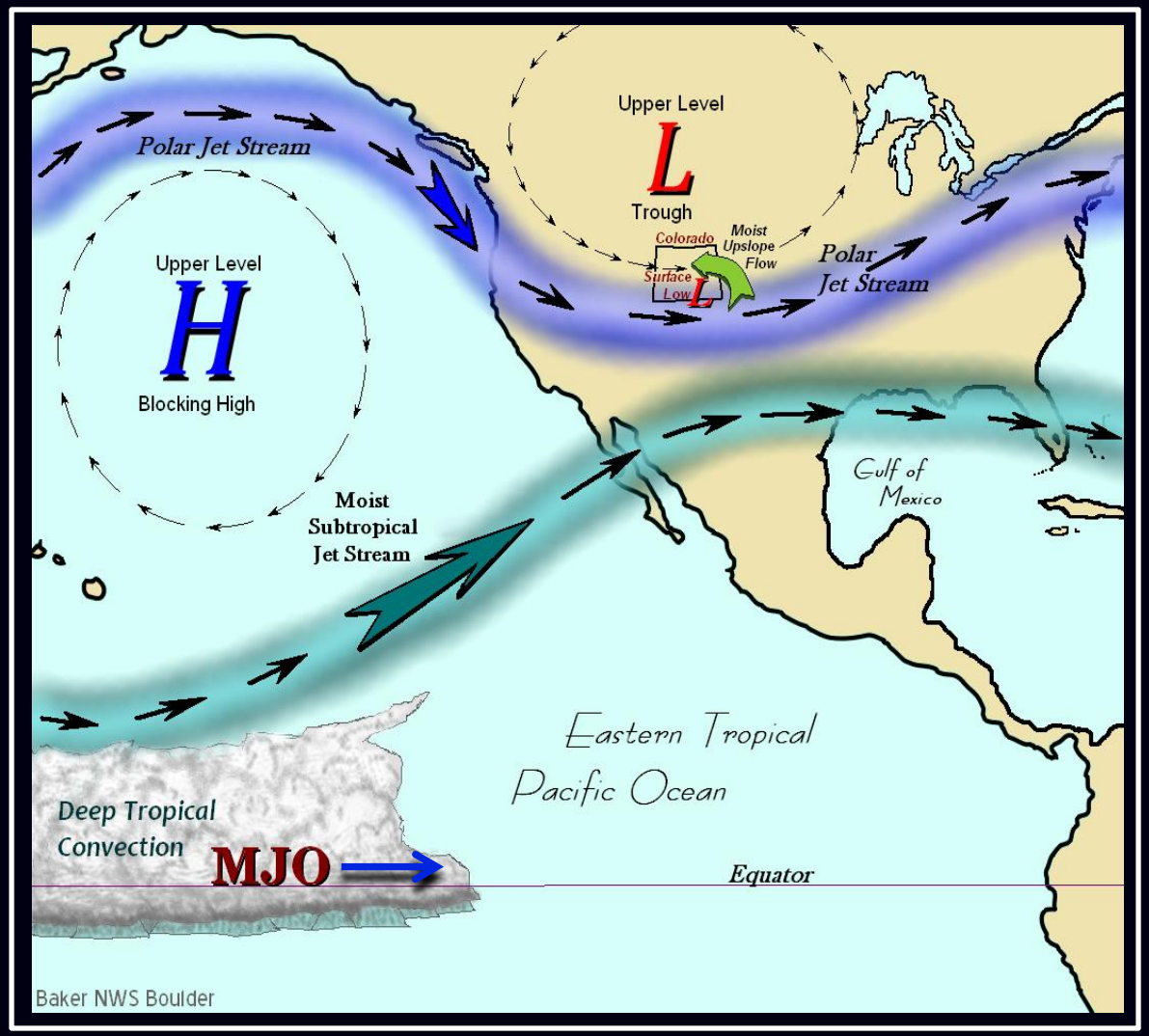
I-25 Urban Corridor Sites	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
Boulder	0.0	0.0	0.0	7.9	0.8	11.7	3.7	**18.5**	**22.8**	**47.6**	na	na
Castle Rock	0.0	0.0	0.0	2.3	0.2	11.3	1.8	**18.8**	**13.9**	**na**	na	na
Denver	0.0	0.0	0.0	5.5	1.7	5.2	4.6	**14.1**	**23.5**	**20.4**	na	na
Greeley (UNC)	0.0	0.0	0.0	2.1	4.7	3.8	0.0	**8.9**	**6.0**	**13.8**	na	na
Lakewood	0.0	0.0	0.0	4.3	1.0	5.8	3.6	**15.8**	**18.4**	**22.8**	na	na
Loveland	0.0	0.0	0.0	5.5	4.8	6.5	2.0	**14.4**	**15.0**	**26.6**	na	na
Northglenn	0.0	0.0	0.0	5.0	1.0	3.3	3.2	**11.5**	**21.5**	**17.6**	na	na
Wheat Ridge	0.0	0.0	0.0	4.4	1.3	5.7	4.5	**16.8**	**21.0**	**29.5**	na	na

Northern Mountain Locations	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
Breckenridge	0.0	0.0	0.0	8.0	4.0	23.9	6.6	**25.4**	**35.6**	**34.7**	na	na
Estes Park	0.0	0.0	0.0	8.1	0.2	15.9	1.7	**7.9**	**14.4**	**42.0**	na	na
Evergreen	0.0	0.0	0.0	5.7	0.3	8.9	3.9	**26.9**	**15.9**	**20.7**	na	na
Grand Lake	0.0	0.0	0.0	4.0	0.7	27.3	16.6	**22.1**	**22.1**	**45.0**	na	na
Kremmling	0.0	0.0	0.0	2.5	3.5	17.7	8.0	**11.5**	**11.3**	**13.6**	na	na
Winter Park	0.0	0.0	0.0	8.0	7.0	33.0	15.0	**21.0**	**24.2**	**37.0**	na	na

North central and northeast Colorado saw a dramatic shift to cold and snowy weather starting in February of this year, after several months of below to well below average snowfall. The fourteen stations listed above saw their greatest monthly snowfall of the 2012-2013 winter season during March and April ; the result of several very moist winter-like storm systems passing through Colorado. Noteworthy snow amounts in April include 42 inches in Estes Park, 45 inches in Grand Lake, and the nearly 48 inches of snow in Boulder.

Baker - National Weather Service Boulder, Colorado

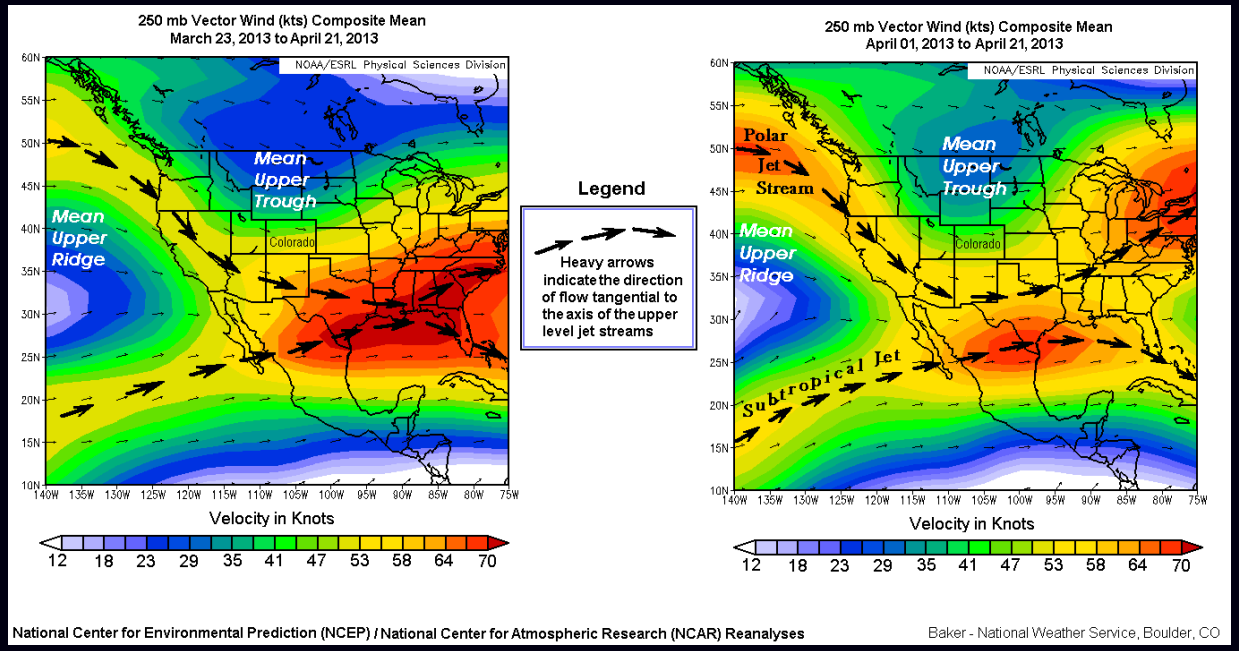
The Polar and Subtropical (Pacific) Jet Streams

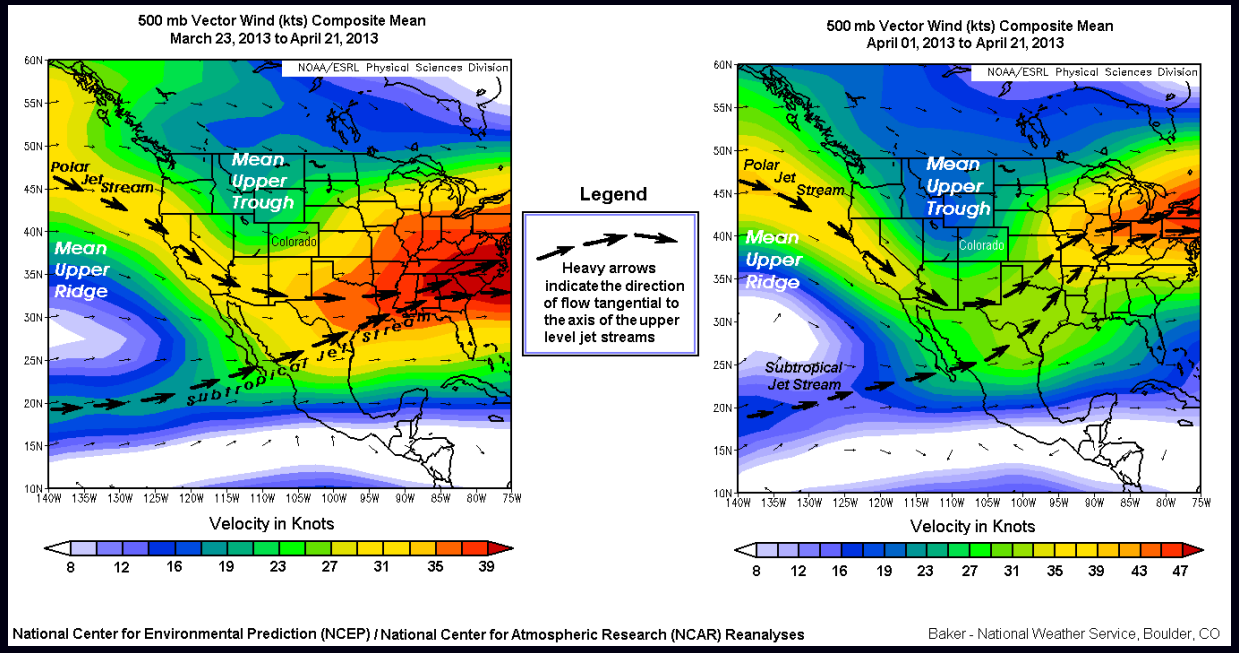


The polar and subtropical jet streams circle the northern hemisphere at an altitude between 18,000 feet ASL (500mb) to 34,000 feet (250 mb).

The jet stream pattern of the past several weeks over the eastern Pacific and North America resembles the large scale circulation that often appears with a Madden-Julian Oscillation (MJO) as it slowly migrates eastward across the eastern tropical Pacific Ocean. Its persistence has far exceeded the duration that normally occurs with a MJO.

The quantity of humid air being transported northward by the current subtropical jet is less than what normally occurs with an MJO or during an El Niño, largely due to the lack of deep convection (thunderstorms) over the slightly cooler than normal tropical Pacific. Yet, it still remains an efficient conveyor of tropical and subtropical moisture for precipitation enhancement for parts of the U.S.



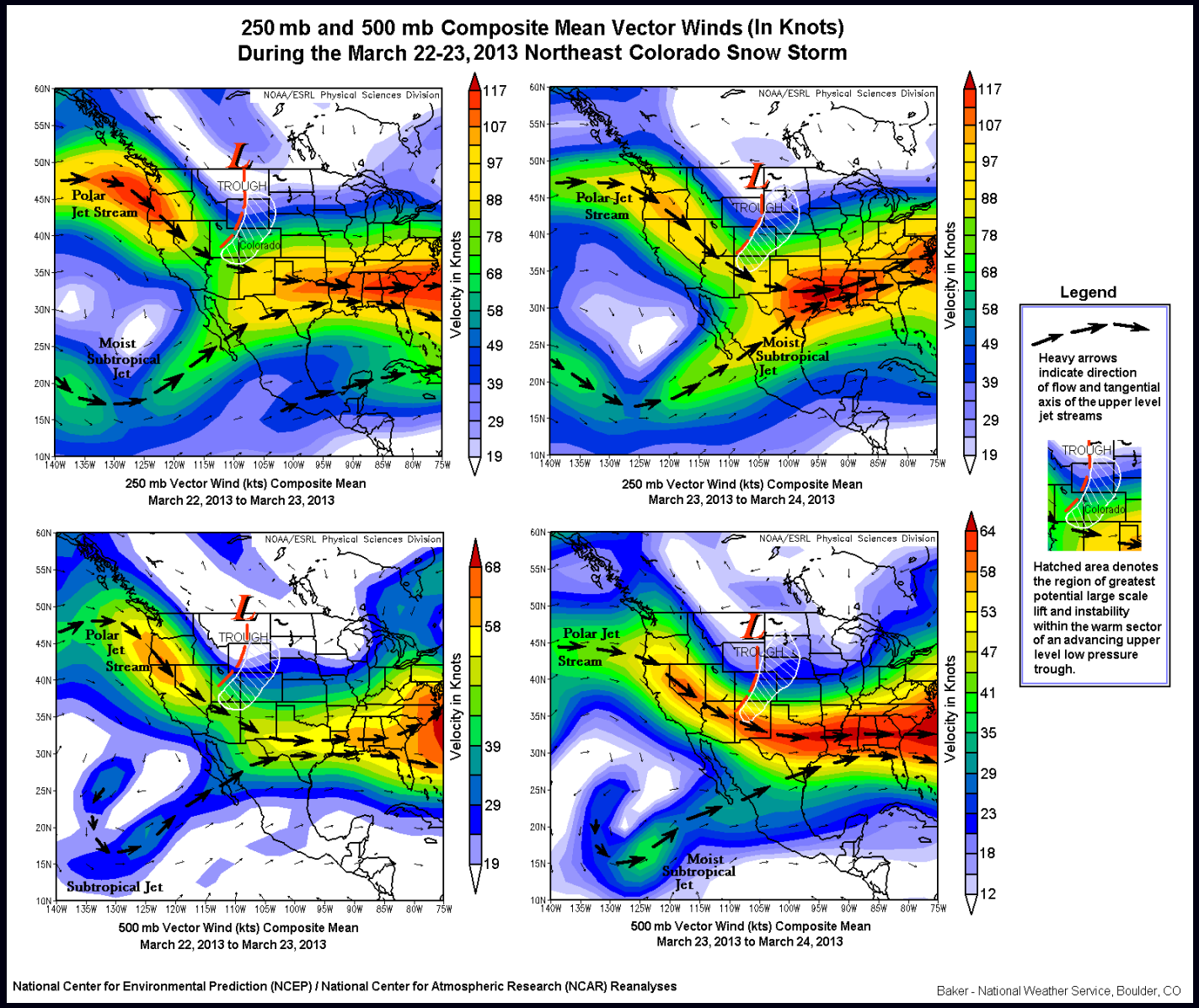


The four composites show the mean position of the Polar jet stream and the subtropical jet stream (also known as the Pacific jet) over the eastern Pacific Ocean and continental U.S. during the 30 day period ending April 21, 2013.

The plots show the prevailing position of the two jet streams at two different altitudes; the 250 millibar level or about 34,000 ft asl, and at the 500 mb level or about 18,000 ft asl.

The left two plots cover the time period March 23 to April 21 of this year, and the right two plots the more recent period of April 1 to 21, 2013.

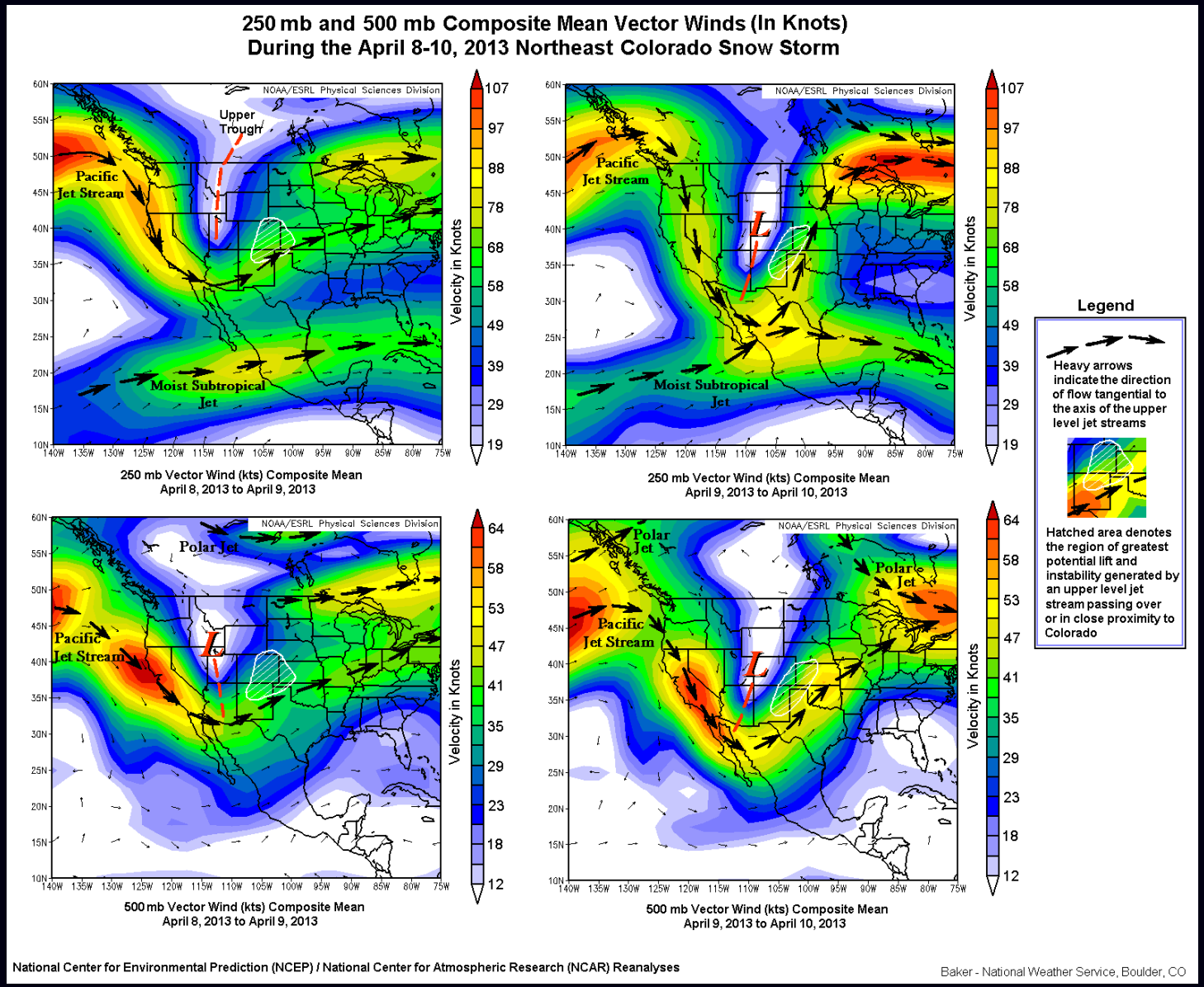
What clearly stands out on these composites is the persistence of a large upper level high pressure ridge over the eastern Pacific and a broad upper level low pressure trough over the western and central U.S. A subtropical jet stream can also be seen crossing over the southern U.S. during the period.



On March 22-23 of this year, northeast Colorado experienced its second major snow storm of the month.

Strong upslope flow following the passage of a cold front, and later the passage of an upper level low pressure trough combined to produce 4 to 10 inches of snow along the east face of the Front Range and the adjacent plains.

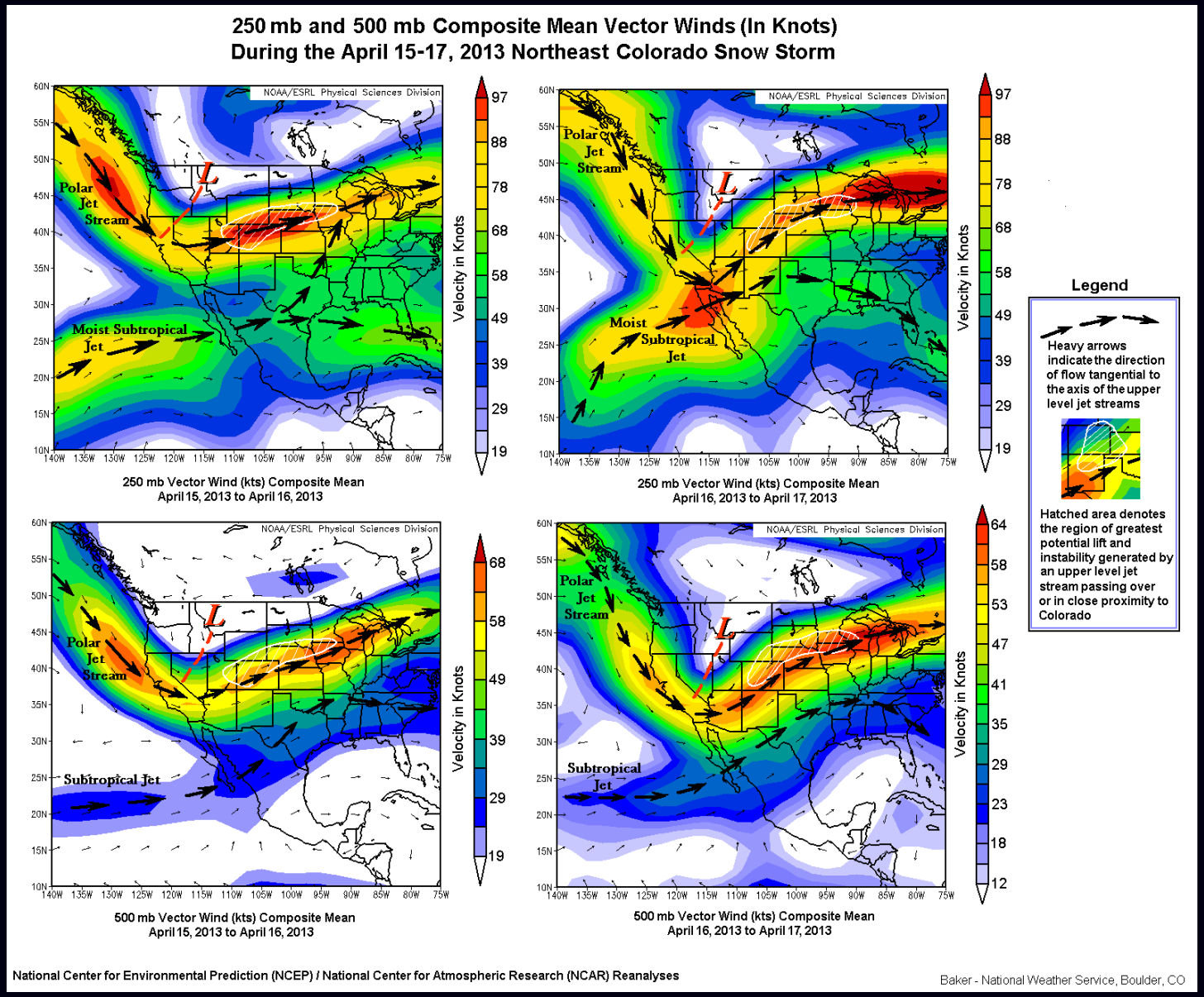
This was principally a cyclone driven upslope snow event with the polar jet stream remaining south of the area during the main period of snowfall. Snow amounts were largely dependent on elevation as so often occurs with upslope precipitation. The higher the elevation, the greater the snow amount.



On April 8-10 of this Year, the third major snow storm since the beginning of March hit the Front Range and nearby high plains of northeast Colorado.

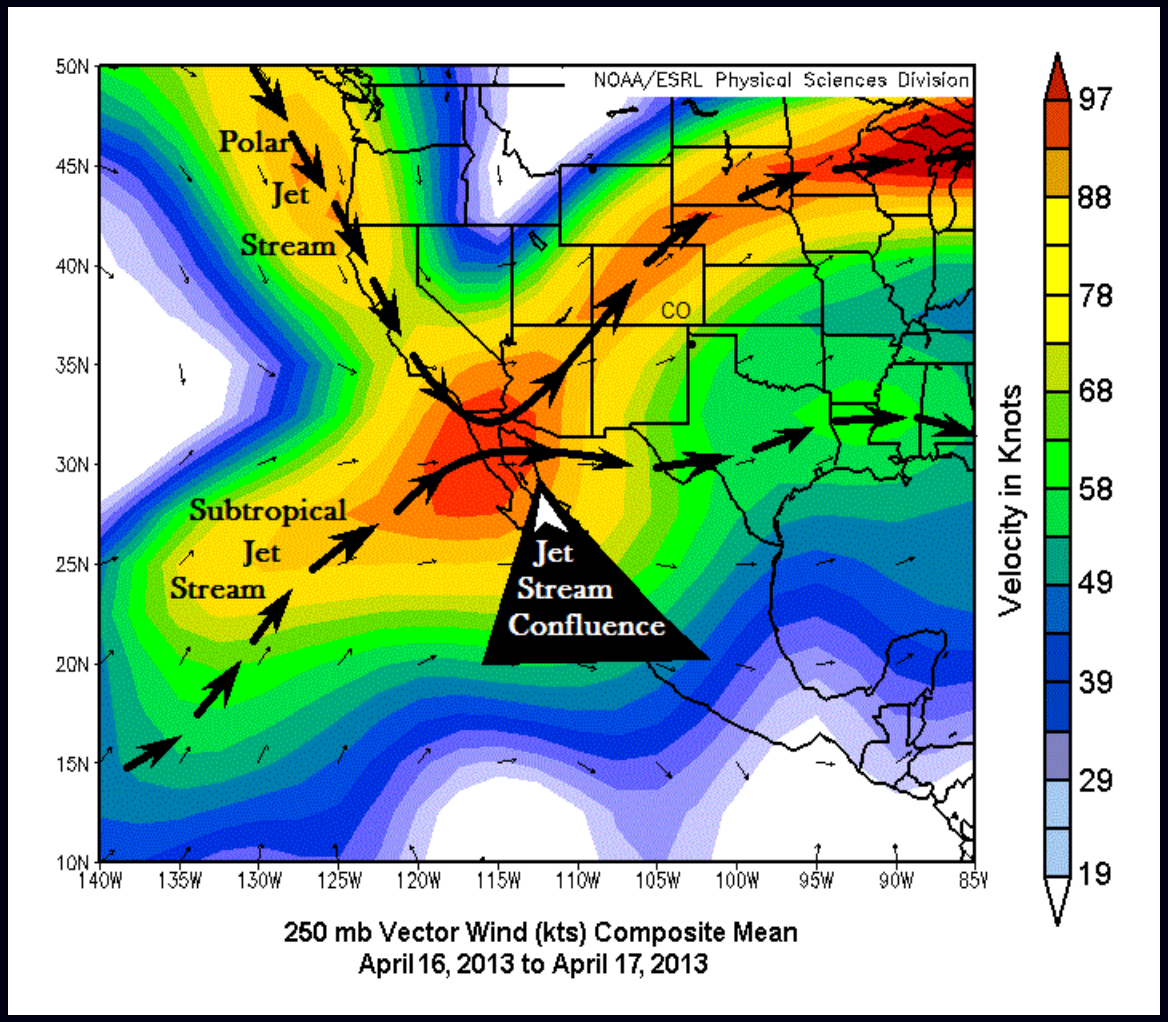
Strong upslope flow following the passage of a cold front, and the lift and instability created by a strong polar jet stream passing overhead generated both upslope snowfall and “banded” snowfall across the region over and along the Front Range.

The heaviest snowfall occurred on the 8th of April when two jet induced bands of heavy snow formed across the northwest Denver metro area and Boulder county. Later snowfall was the product of lift largely generated by upslope.



The snow storm of April 15-17 of this year, was the forth storm back to the first of March to deposit a substantial amount of snow on the Front Range and nearby high plains of northeast Colorado.

Snow, at times heavy, began over the northern Front Range on the 15th as the core of a powerful polar jet stream passed over the area. (Refer to left two plots.) Parts of Larimer County up around Fort Collins saw 1 to 2 inch per hour snowfall rates during the day. As the core of the jet slowly migrated southward, so did the bands of heavy snowfall. Late on the 15th and early on the 16th, strong upslope flow was helping to enhance snowfall in the Denver area.



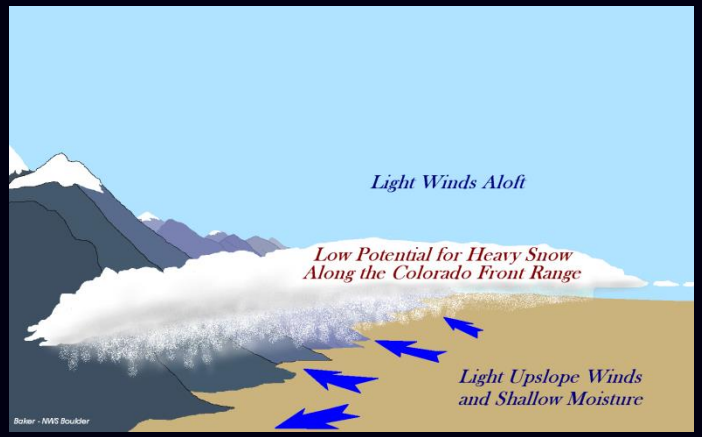
The infusion of moist air into the polar jet stream by the subtropical jet helped set the stage for the heavy snow that buried the Colorado Front Range April 15-17th. This collision or confluence of jets has been linked to past heavy precipitation events in Colorado. The April 15-18th snow storm came close to being one of those "really big" storms that people talk about for years, such as the March Blizzard of 2003.

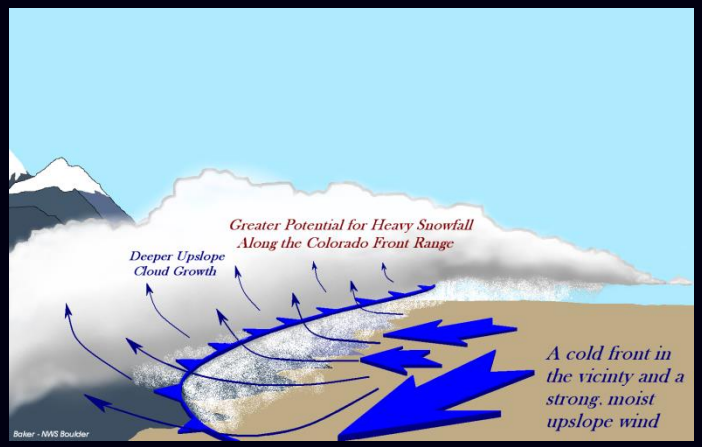
What's Colorado's Connection to the Subtropical Jet Stream?

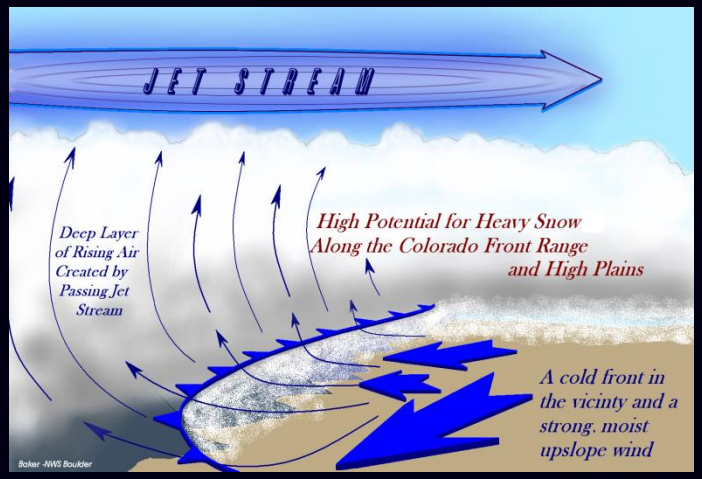
We've discussed the importance of the polar jet stream as a mover of air masses, storm systems and moisture. This meandering river of strong winds aloft also provides the vertical shear necessary to generate powerful thunderstorms.

The subtropical jet stream, on the other hand, is the principal transporter of air laden with moisture from the tropical and semi-tropical regions of the Pacific. It is also a conveyor of bundles of atmospheric energy spun off from deep convection in the tropics.

The Challenge of Predicting Snow, Particularly Heavy Snowfall, Along the Colorado Front Range





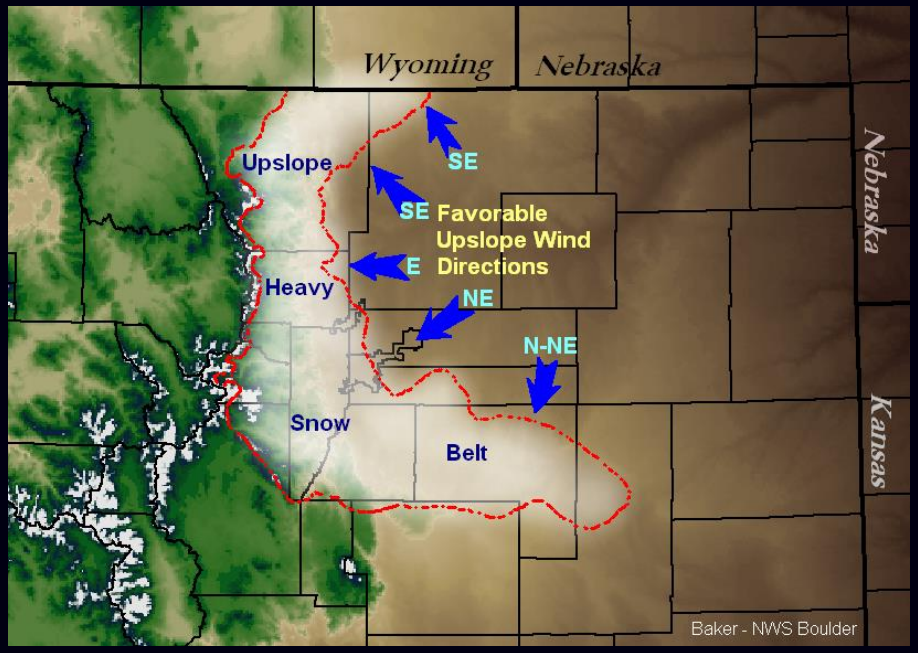


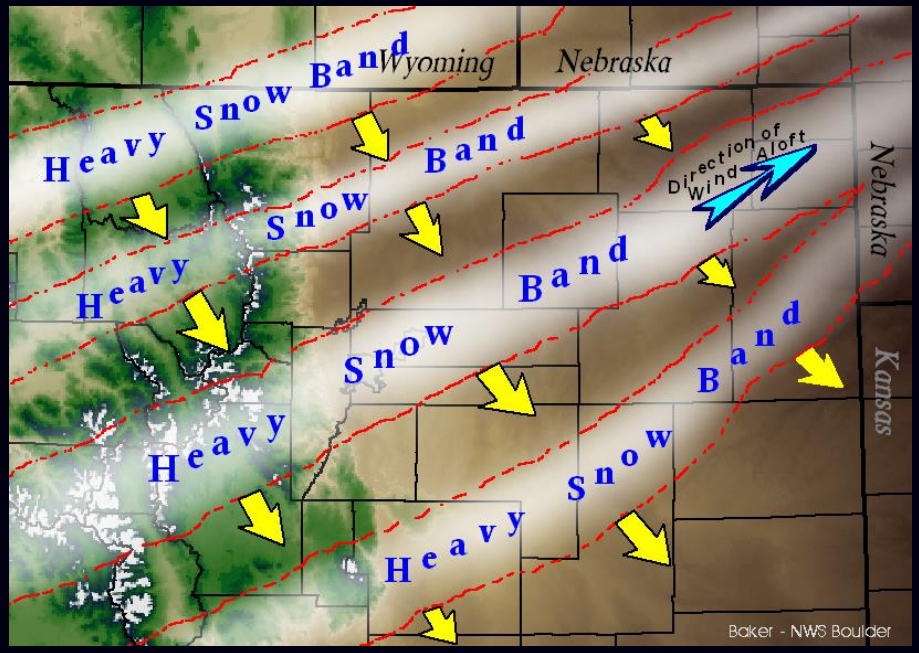
Predicting the beginning and end of snowfall over and along the Colorado Front Range can be a difficult challenge.

Predicting where it will snow and how much can be just as challenging. Recognizing the complex processes that will generate this precipitation is very important.

Along the Colorado Front Range, there are two principal lifting mechanisms for snow production. The first being "upslope" or orographic lift. The second is the large scale lifting of air and the instability created by a passing jet stream. For the sake of simplicity, a weak or shallow upslope flow (a wind possessing an east or northeast component) will generally produce only light snowfall up against the Front Range foothills (top diagram). Stronger and more moist upslope flow following the passage of a cold front will usually produce a deeper cloud layer capable of producing moderate to heavy snowfall over and near the Front Range (middle diagram). The heaviest snowfall will normally occur with post-frontal upslope flow and in the presence of a strong jet stream. The passing jet further destabilizes mid and upper levels of the atmosphere and creates a deep layer of rising air (lower diagram). This snowfall is often "banded" in nature (described on next slide).

Upslope Snowfall Versus Jet Stream Enhanced or Banded Snowfall



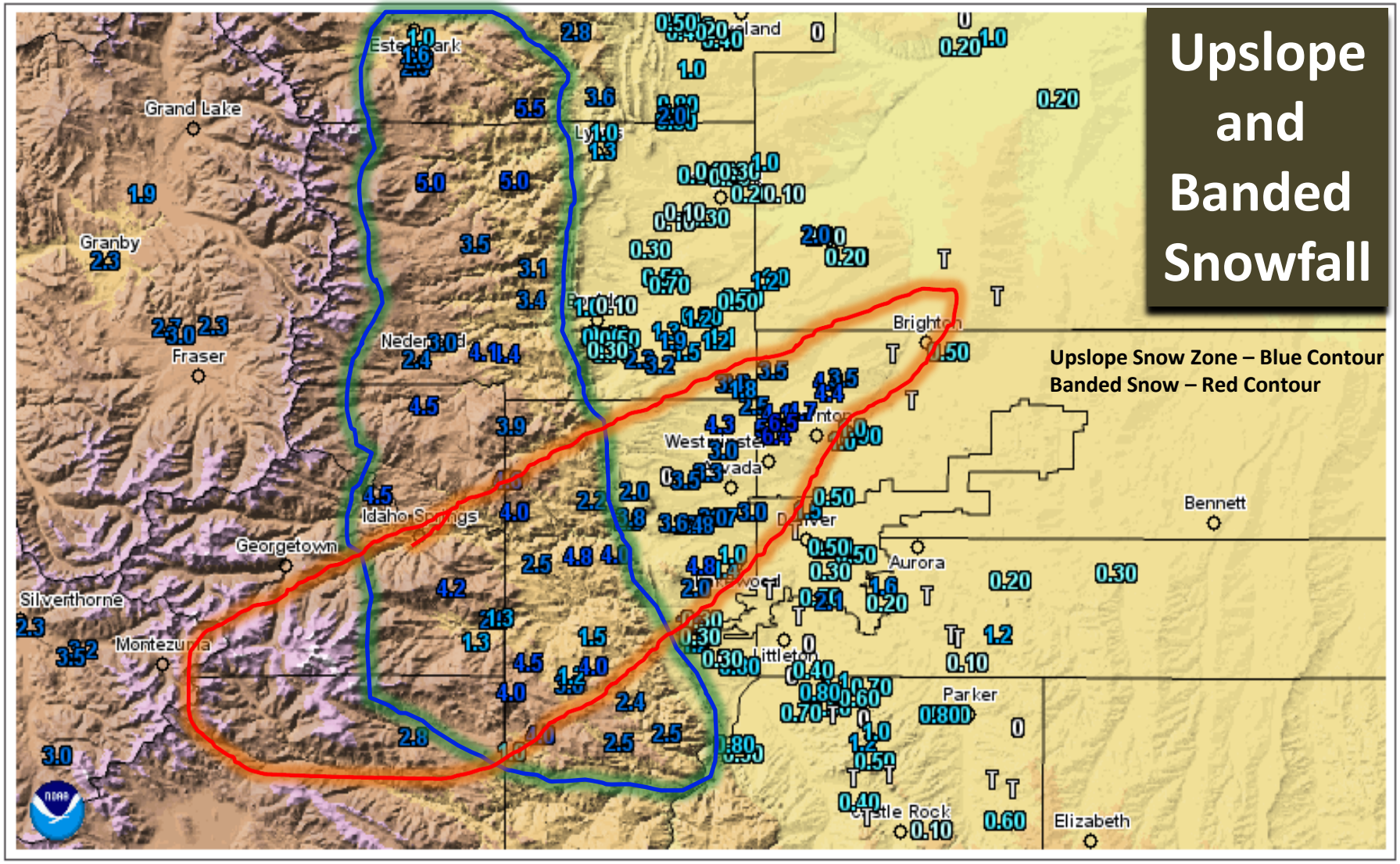


The upper left diagram identifies the surface or low-level wind component most likely to produce significant “upslope” snowfall along the east face of the Colorado Front Range.

Northern portions of the Front Range, such as around Fort Collins, require a southeast wind to generate enough lift necessary for moderate to heavy snowfall in that area. Southern sections rely on an east or northeast wind to produce adequate lift for substantial snowfall.

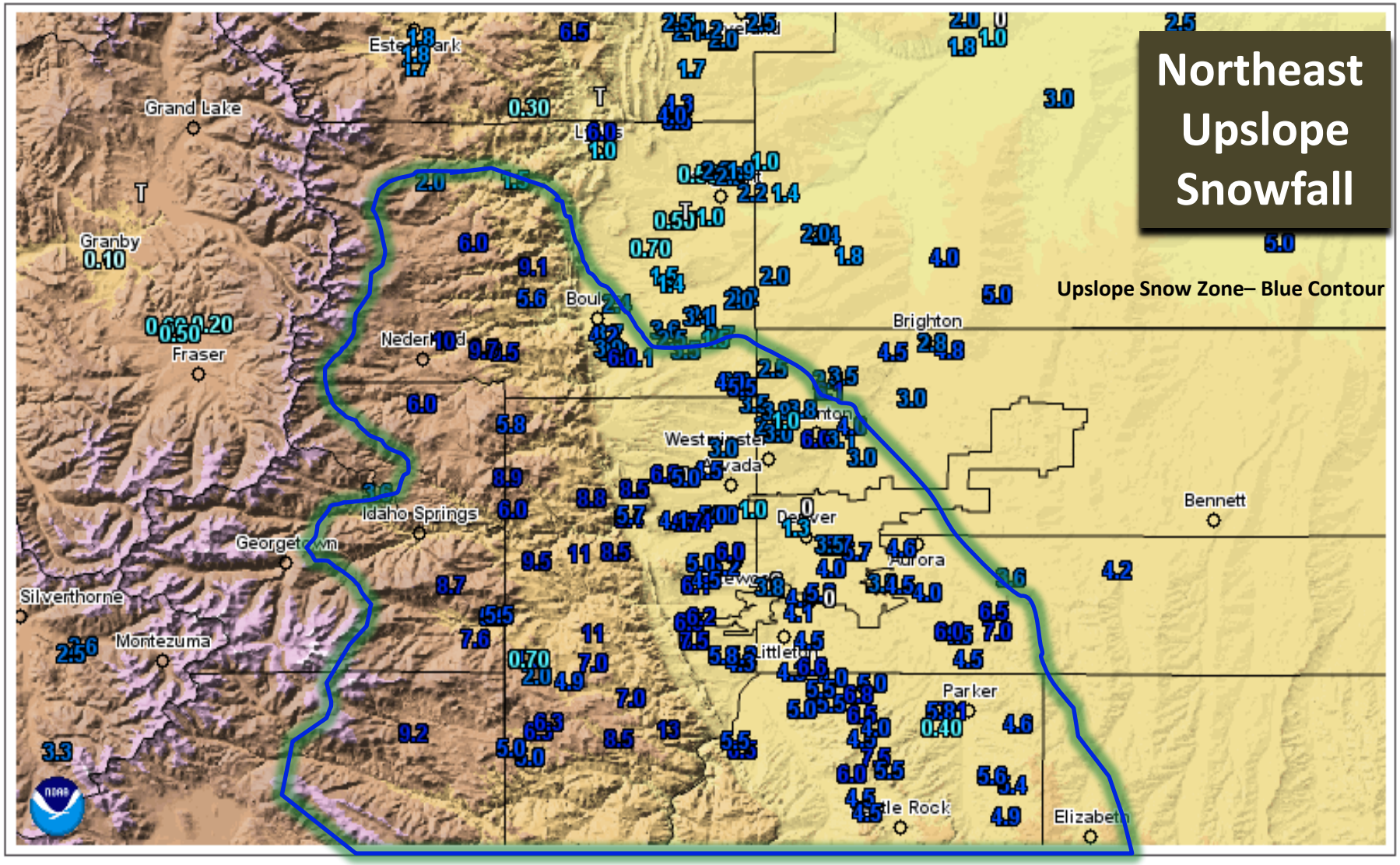
The upper right diagram reveals a less common snow-making process; jet enhanced or “banded” snowfall. This process can produce a substantial amount of snow in a relatively short period of time.

For this lifting process to produce heavy snowfall, there must be a moist, deep upslope flow in the presence of strong cold front and the core of a strong jet stream immediately upstream or just to the south of the area. These bands will normally move at a right angle to the jet stream wind.



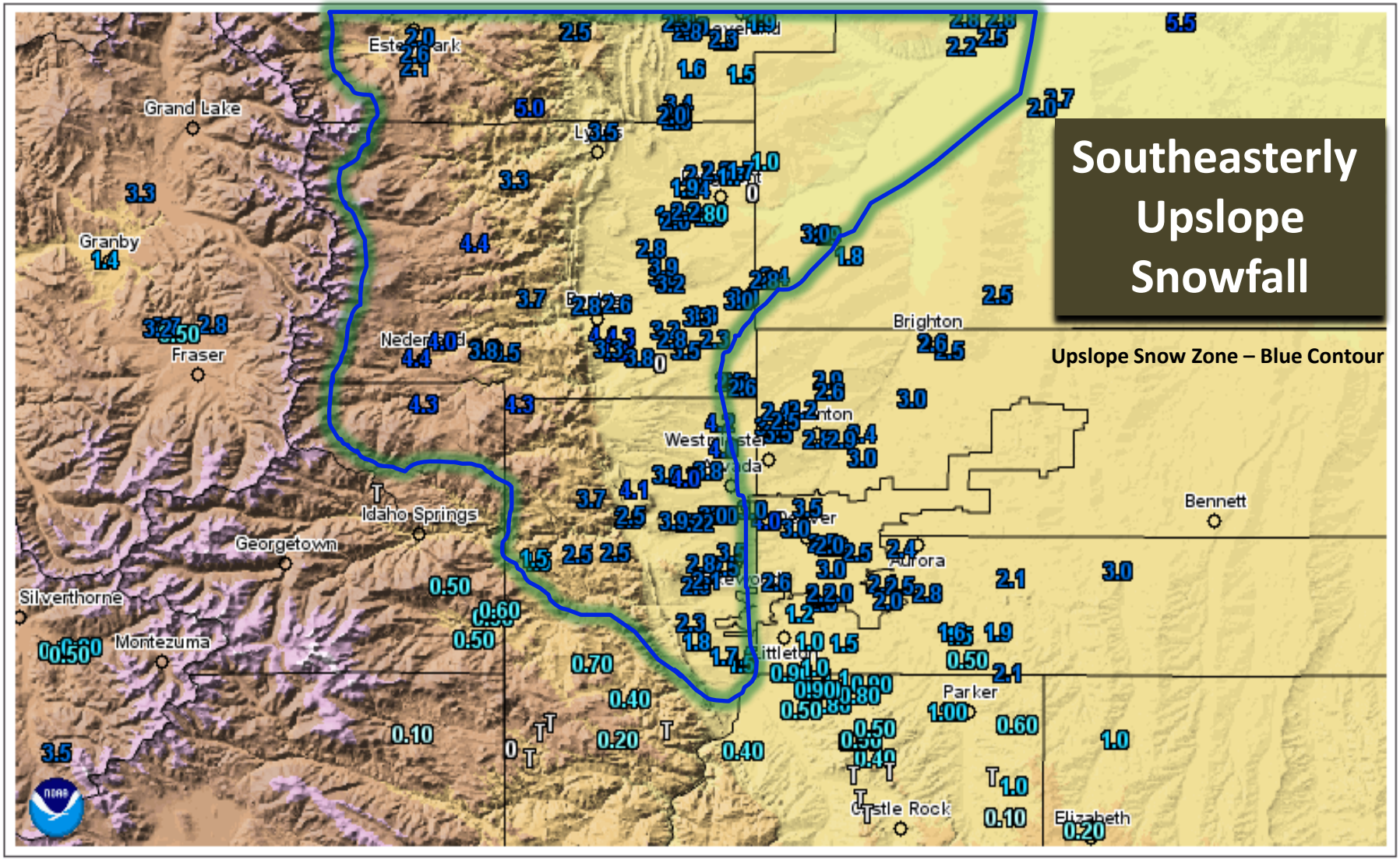
Denver Area 24-Hour Snowfall as of 11 AM MST March 09, 2013

NOAA/National Operational Hydrologic Remote Sensing Center (NOHRSC) Raw Snowfall Reports



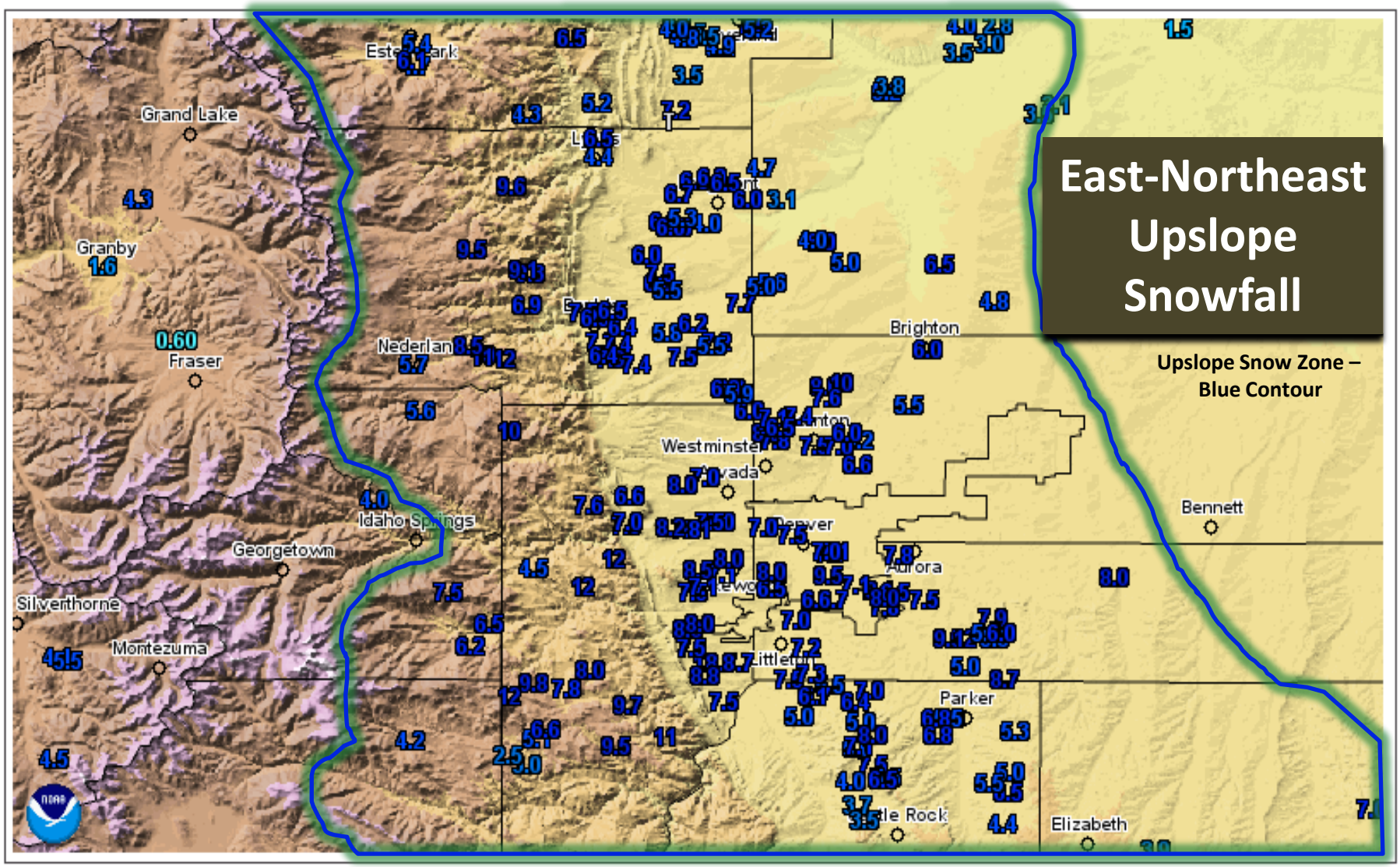
Denver Area 24-Hour Snowfall as of 12 Noon MDT March 10, 2013

NOAA/National Operational Hydrologic Remote Sensing Center (NOHRSC) Raw Snowfall Reports



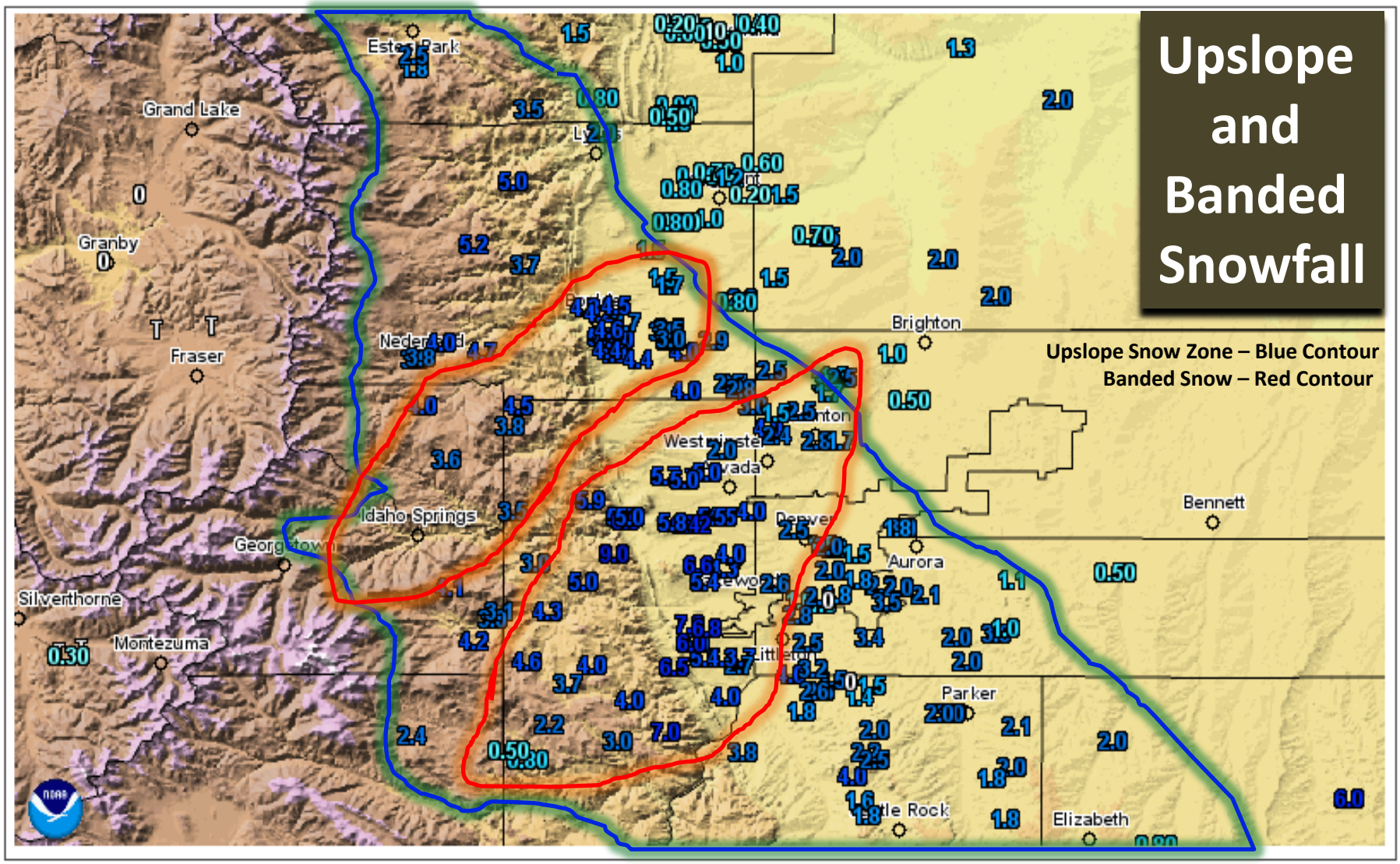
Denver Area 24-Hour Snowfall as of 12 Noon MDT March 12, 2013

NOAA/National Operational Hydrologic Remote Sensing Center (NOHRSC) Raw Snowfall Reports



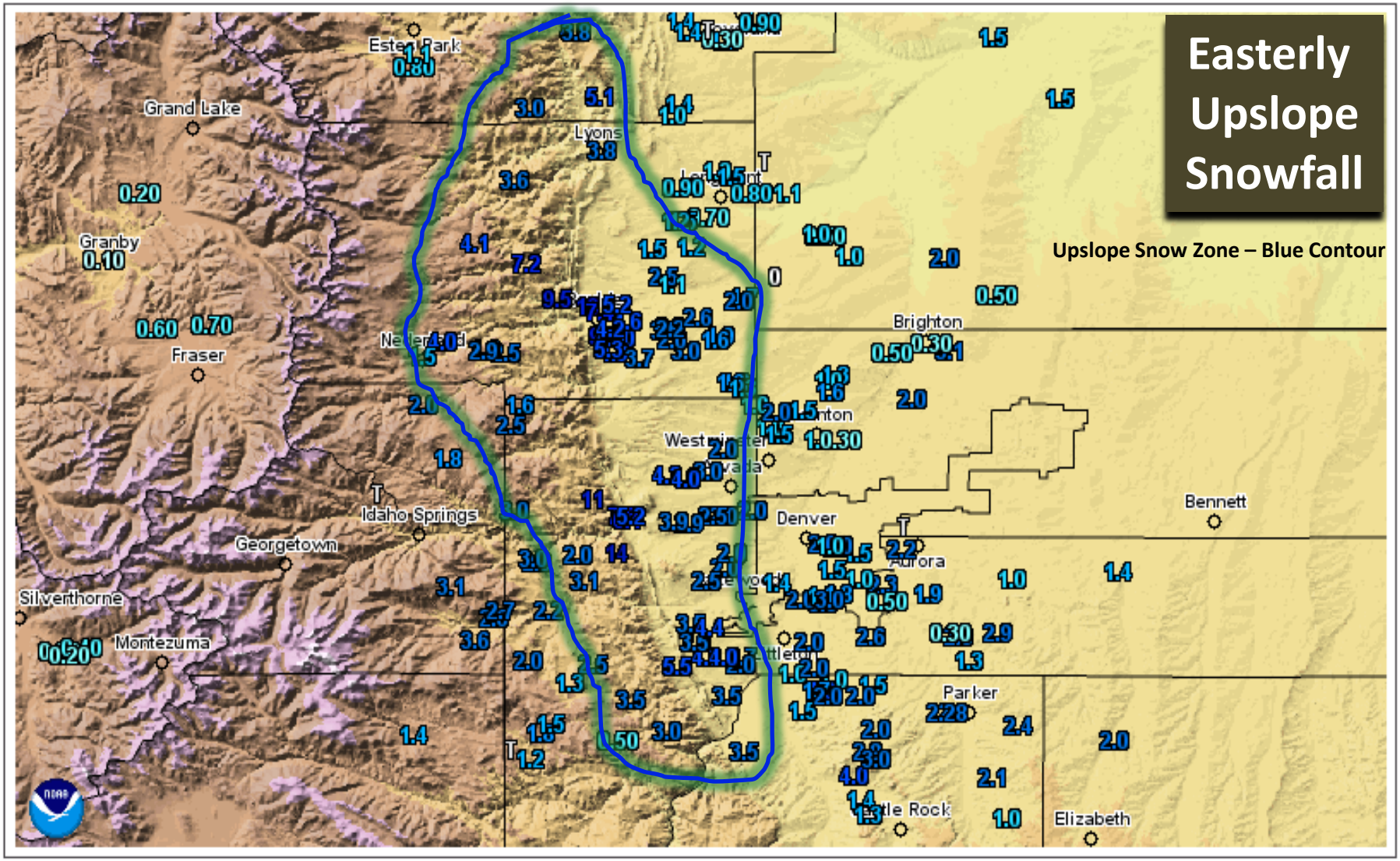
Denver Area 24-Hour Snowfall as of 12 Noon MDT March 23, 2013

NOAA/National Operational Hydrologic Remote Sensing Center (NOHRSC) Raw Snowfall Reports



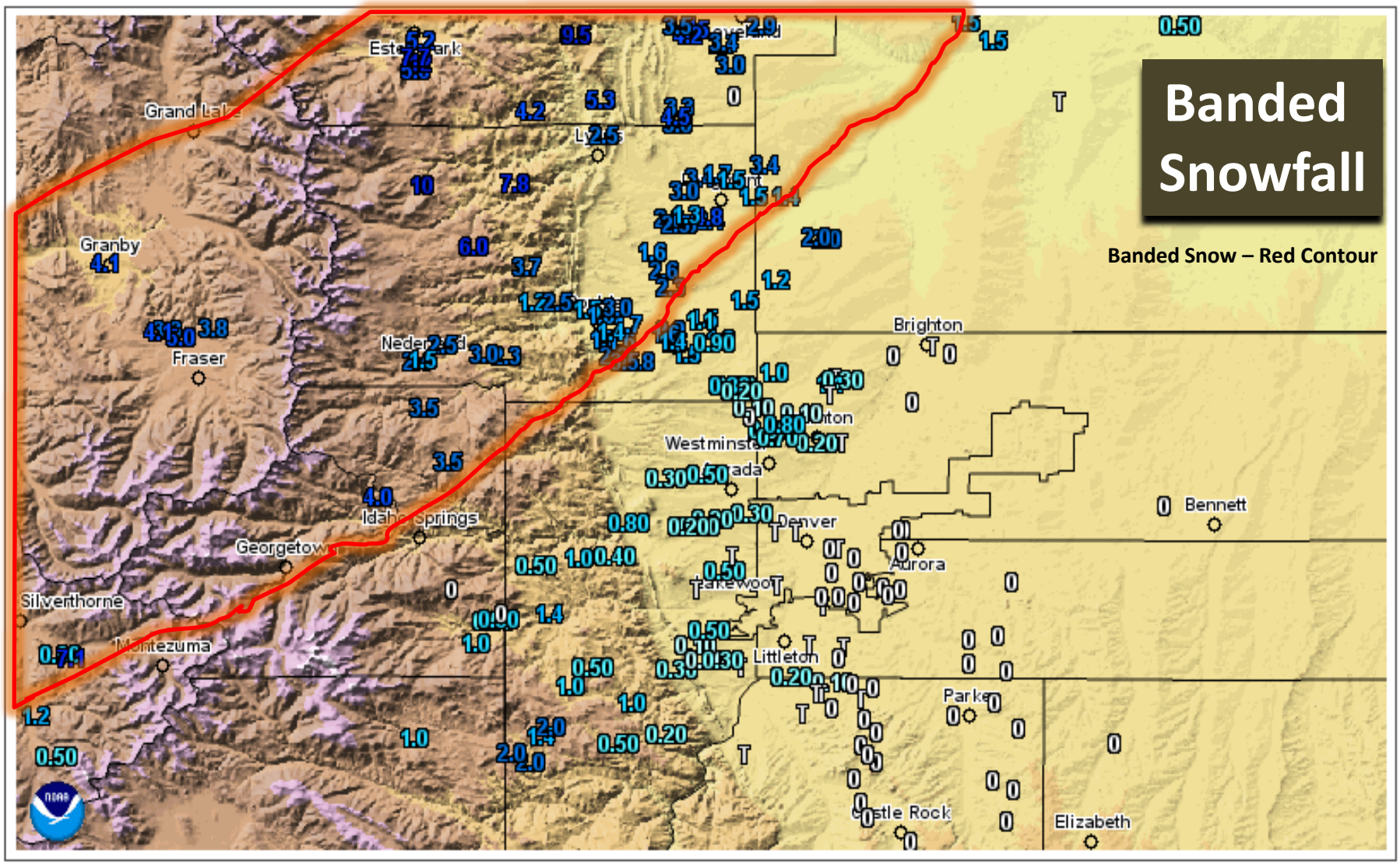
Denver Area 24-Hour Snowfall as of 12 Noon MDT April 09, 2013

NOAA/National Operational Hydrologic Remote Sensing Center (NOHRSC) Raw Snowfall Reports



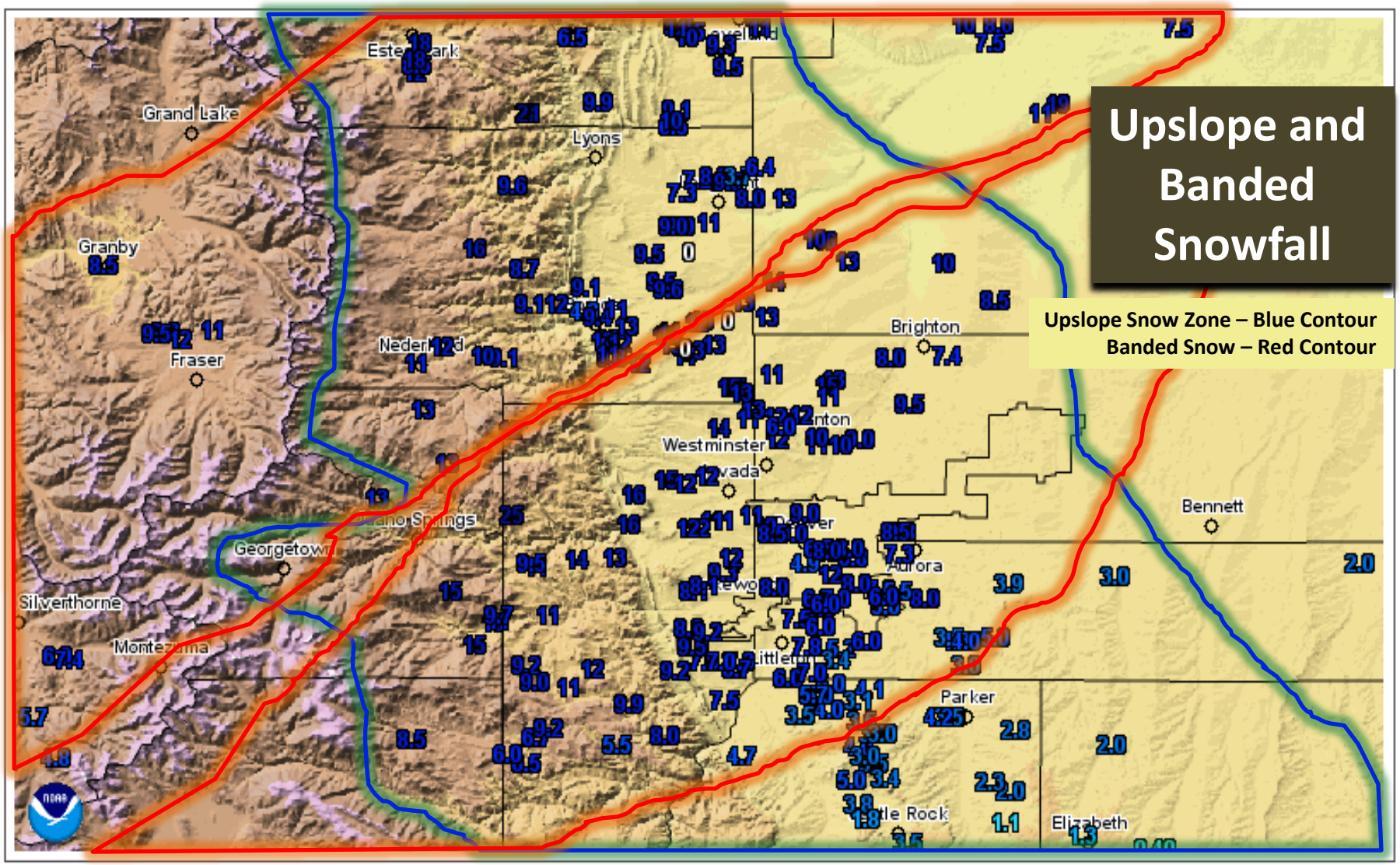
Denver Area 24-Hour Snowfall as of 12 Noon MDT April 10, 2013

NOAA/National Operational Hydrologic Remote Sensing Center (NOHRSC) Raw Snowfall Reports



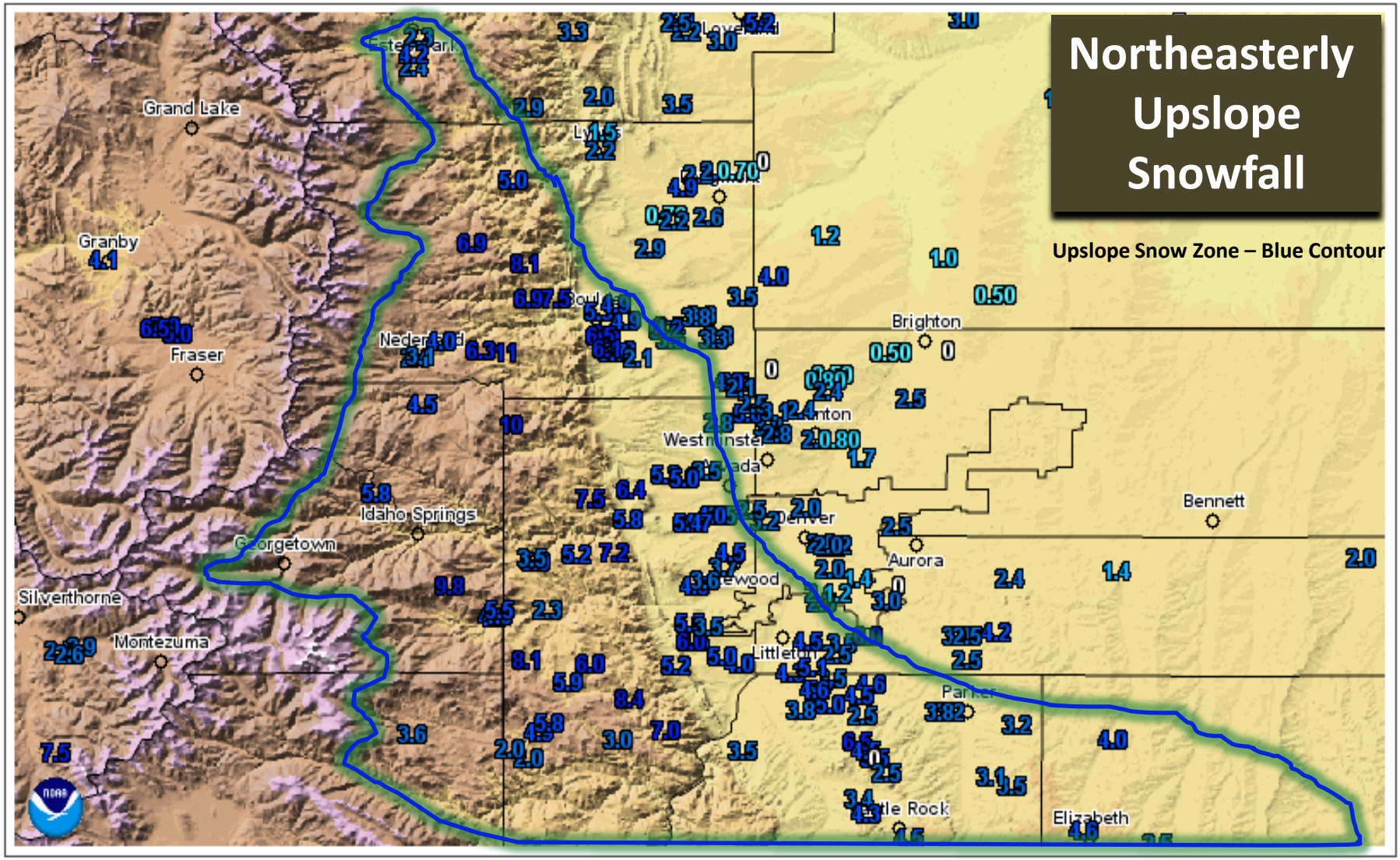
Denver Area 24-Hour Snowfall as of 12 Noon MDT April 15, 2013

NOAA/National Operational Hydrologic Remote Sensing Center (NOHRSC) Raw Snowfall Reports



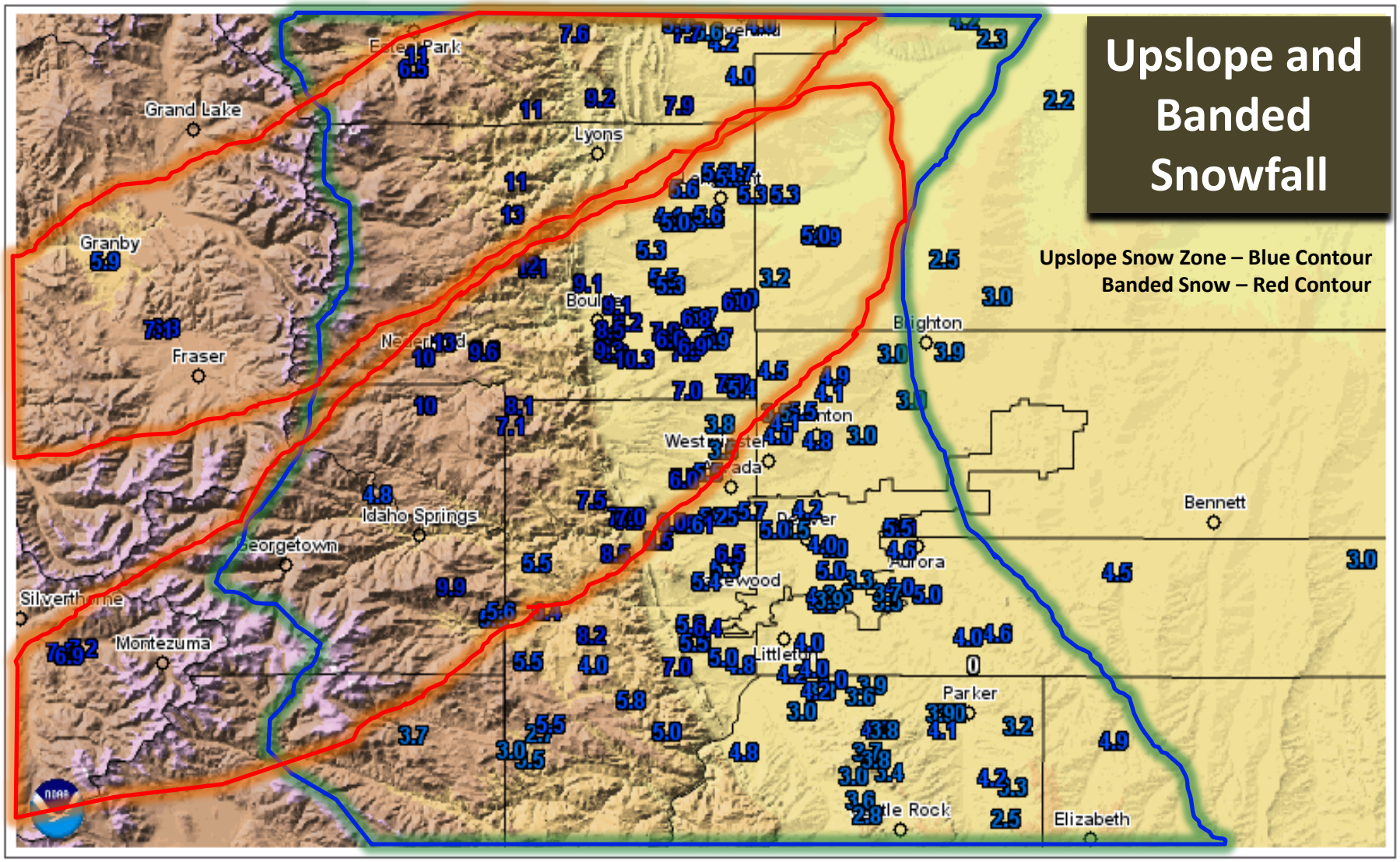
Denver Area 24-Hour Snowfall as of 12 Noon MDT April 16, 2013

NOAA/National Operational Hydrologic Remote Sensing Center (NOHRSC) Raw Snowfall Reports



Denver Area 24-Hour Snowfall as of 12 Noon MDT April 18, 2013

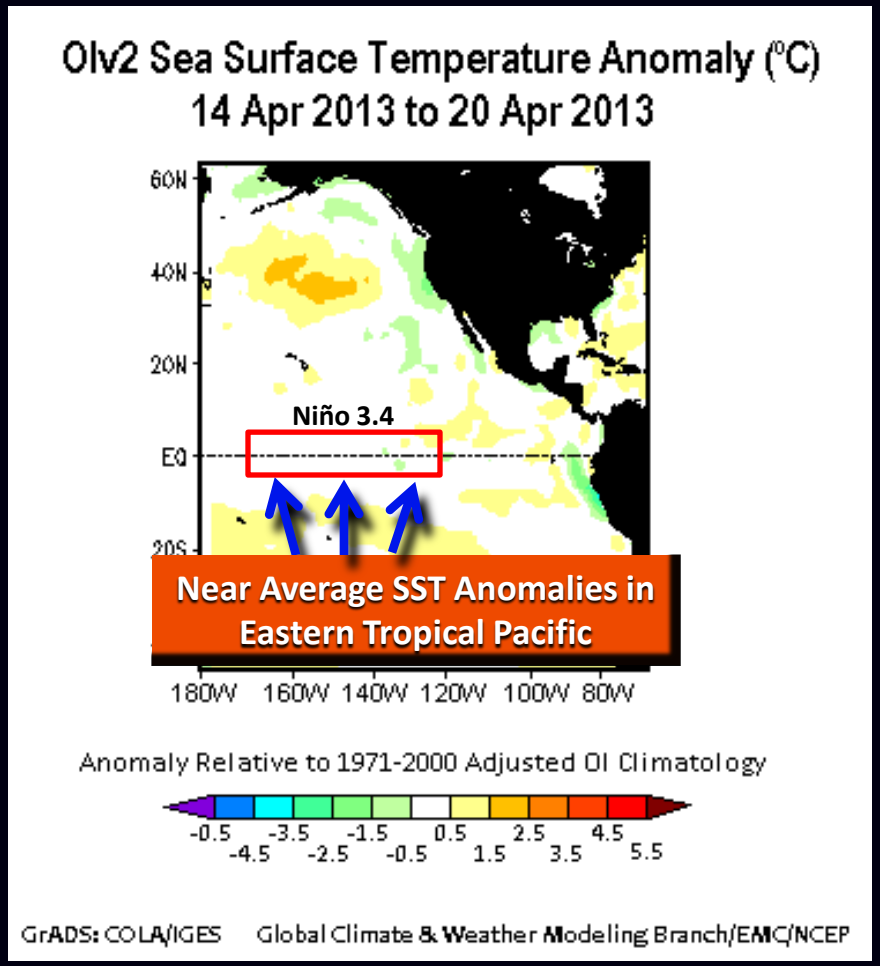
NOAA/National Operational Hydrologic Remote Sensing Center (NOHRSC) Raw Snowfall Reports



Denver Area 24-Hour Snowfall as of 12 Noon MDT April 23, 2013

NOAA/National Operational Hydrologic Remote Sensing Center (NOHRSC) Raw Snowfall Reports

Neutral ENSO Conditions Prevail in the Pacific

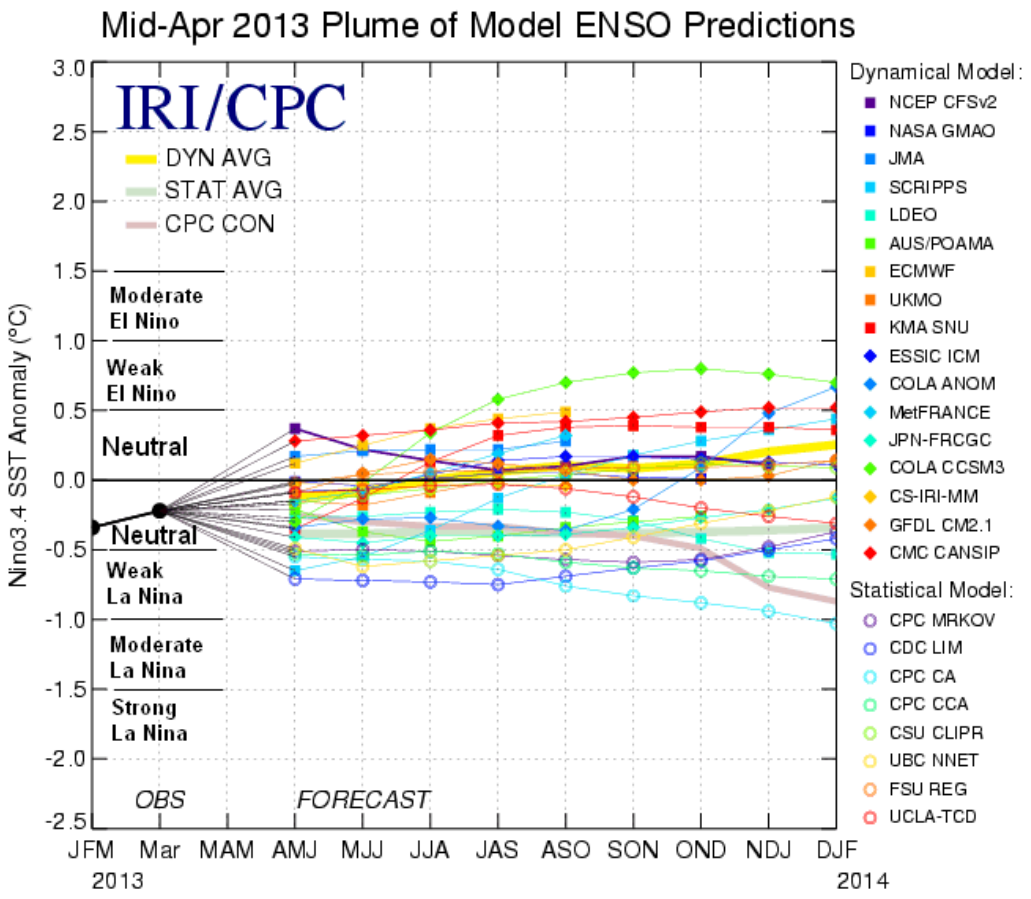


Current ENSO Status – Neutral

During the past several weeks, near average sea surface temperatures (SST) dominate the eastern tropical Pacific Ocean.

However, pockets of warmer-than-average sea surface water east of 120 W longitude continue to generate areas of enhanced tropical convection along the equator. In other areas of the eastern equatorial Pacific, such as along the west coast of South America, SST anomalies have cooled to values associated with a weak La Niña.

Niño 3.4 – The principal region in the eastern Equatorial Pacific Ocean (red outlined box along the equator) used by the Climate Prediction Center (CPC) for monitoring, assessing and predicting the El Niño-Southern Oscillation (ENSO).



	AMJ	MJJ	JJA	JAS	ASO	SON	OND	NDJ	DJF
Average, dynamical models	*-0.1*	*-0.1*	*0*	*0.1*	*0.1*	*0.1*	*0.1*	*0.2*	*0.3*
Average, statistical models	*-0.4*	*-0.4*	*-0.3*	*-0.3*	*-0.3*	*-0.3*	*-0.3*	*-0.3*	*-0.2*
Average, all models	-0.2	-0.2	-0.1	-0.1	0	-0.1	0	0	0

Source: International Research Institute for Climate and Society (IRI) – Apr 18 2013

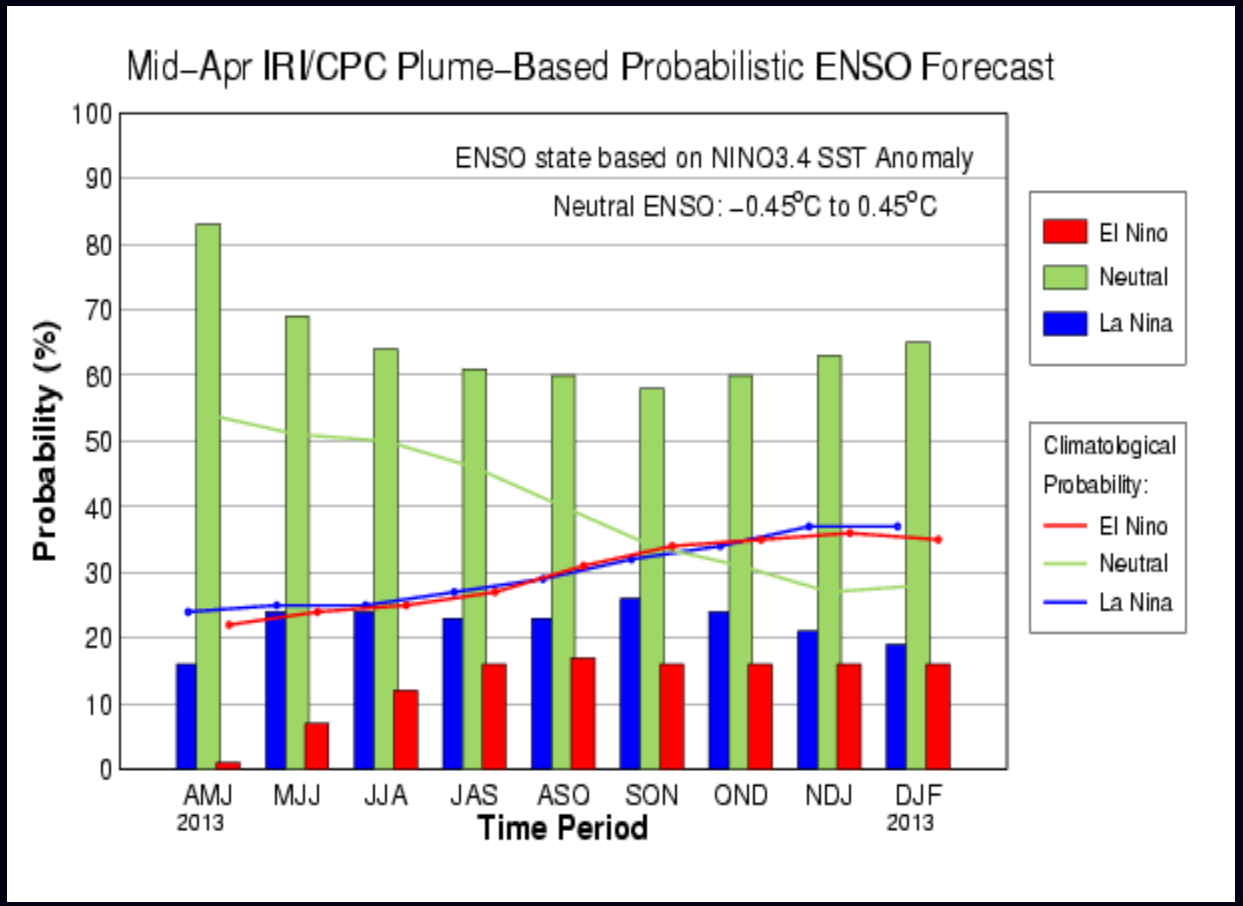
The Forecast for ENSO

An overwhelming majority of the dynamical and statistical climate models continue to predict non-ENSO or neutral conditions in the Pacific Ocean through at least the summer of 2013.

The table at the lower left contains the cumulative average of sea surface temperature anomalies (SSTa) forecasted by 17 dynamical models and 8 statistical models, and a cumulative average for all 25 models for overlapping 3-month climate seasons through the December-February (DJF) 2013-2014.

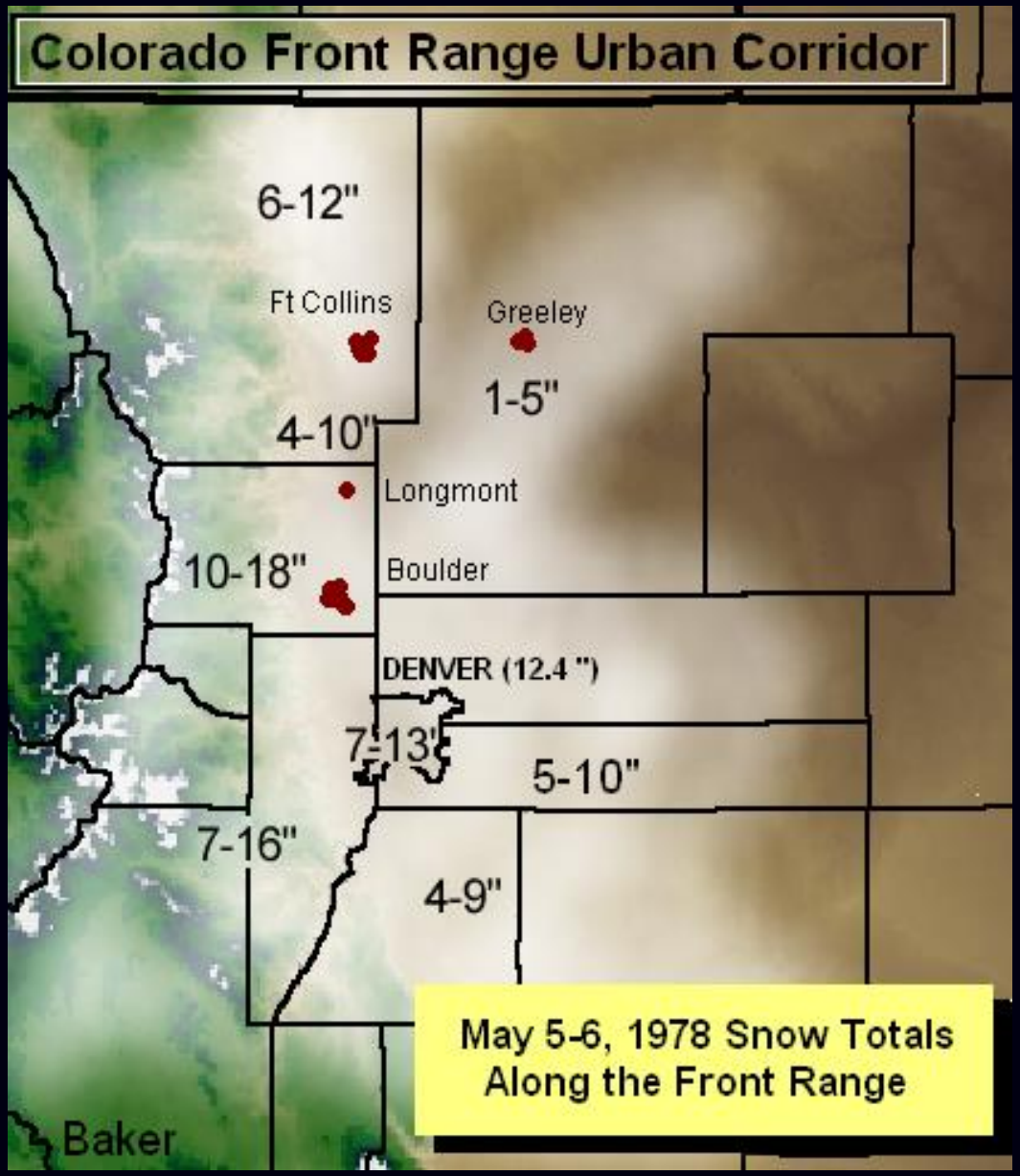
An SST anomaly greater than -0.45˚C and lower than +0.45˚C indicates neutral ENSO conditions.

Probabilistic ENSO Forecast for Nine Overlapping 3-Month Climate Seasons Through December-February of 2013-2014



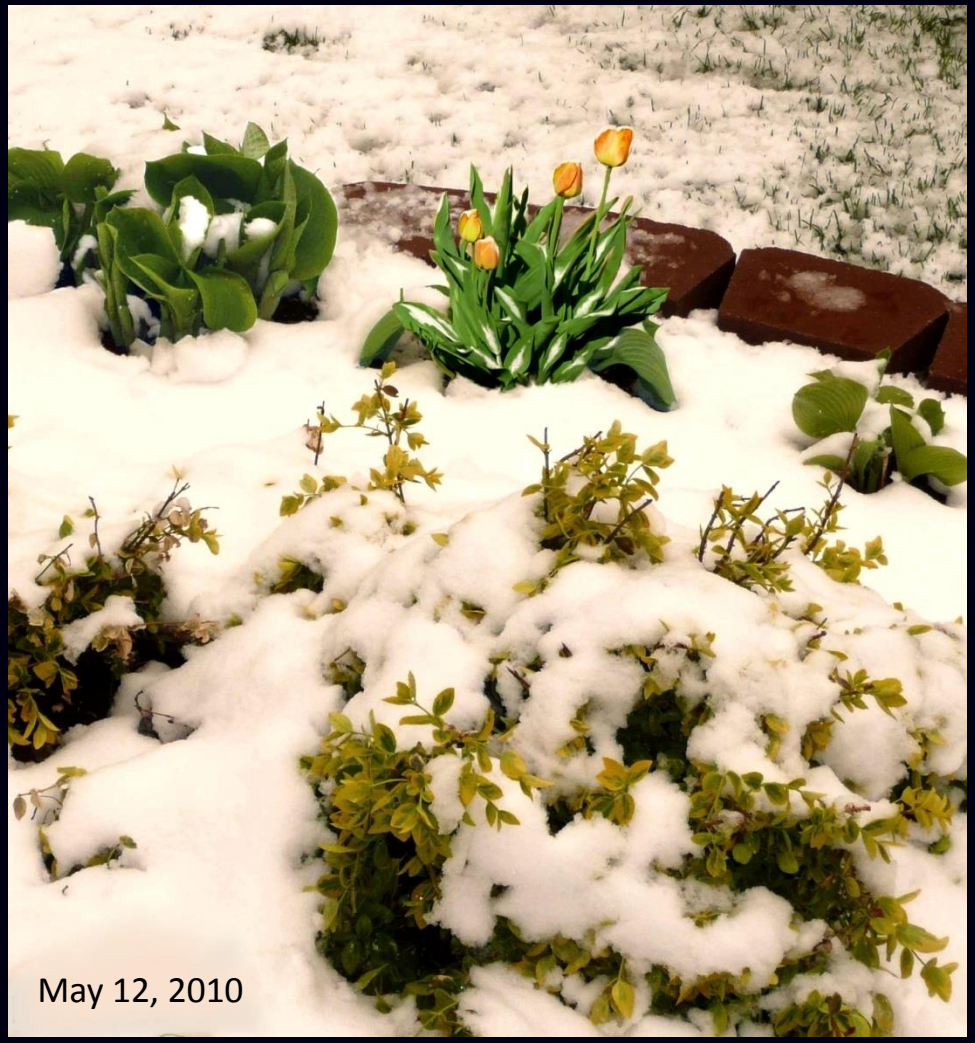
Neutral ENSO conditions are predicted to continue through at least the summer season of 2013, and possibly well into the winter season of 2013-2014.

Models predict an increased probability of a La Nina forming this fall, only to have odds of it occurring weaken there after.



So, with neutral ENSO conditions through May and beyond, what are our chances of seeing more snow along the Colorado Front Range in May?

If recent history is any indicator, don't rule it out. However, May is climatologically speaking one of the least snowiest months of the year for the region.

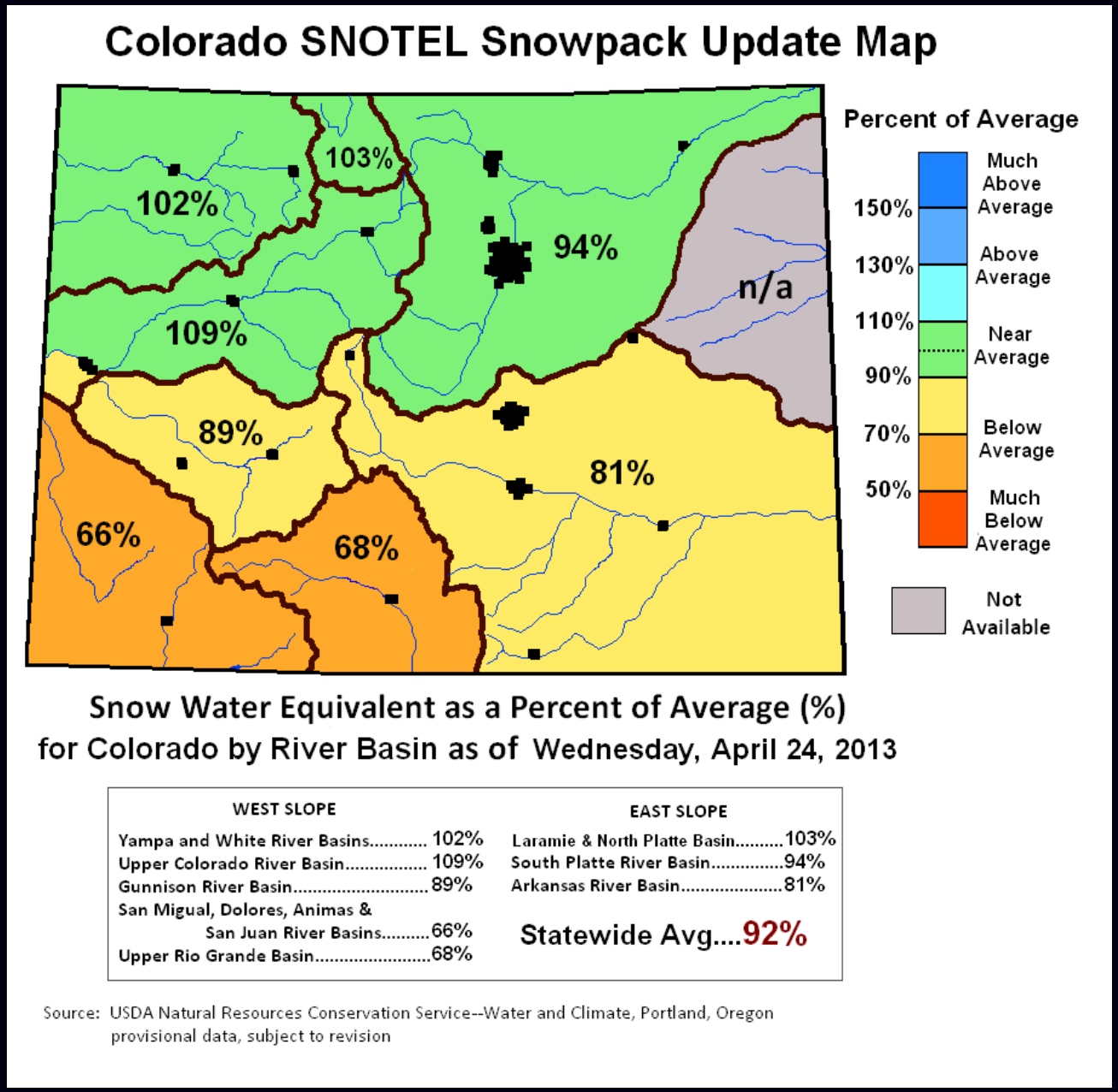


Of the top 30 snow days in Denver since 1950 , 13 of them or 43 percent, occurred during ENSO neutral conditions.

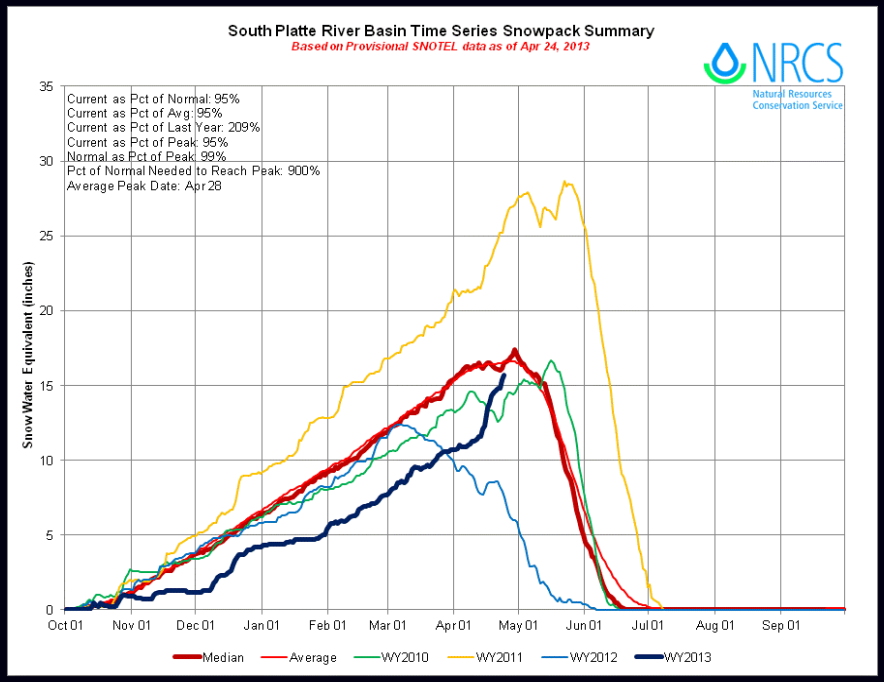
Denver Top 30 Highest Daily Snowfalls (in inches)
During the Month of May from 1950 to 2012
Date during ENSO Neutral Conditions (RED highlight)

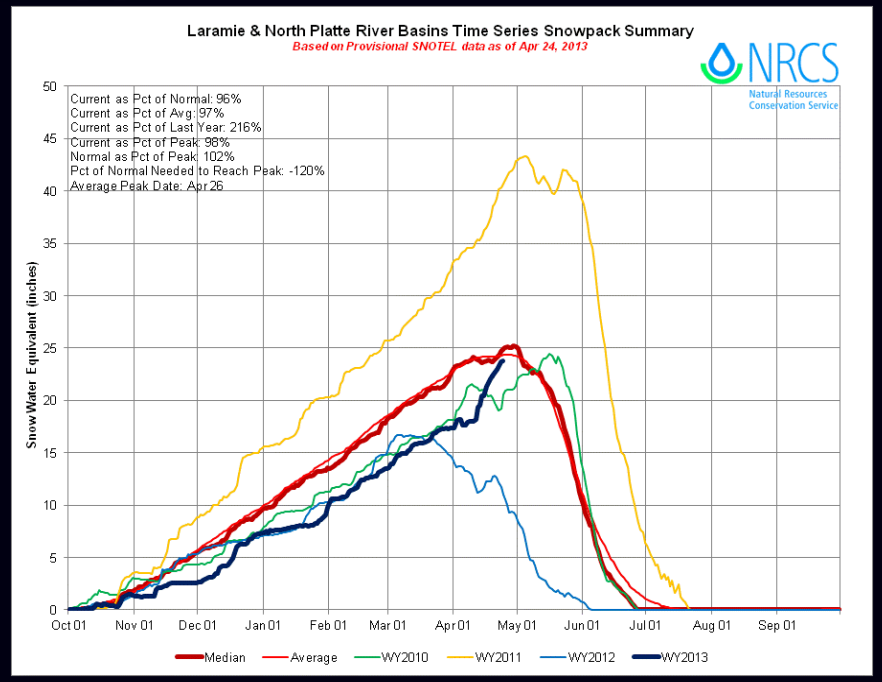
Rank	Snow Total	Date		
1	9.3	5/25/50		
2	7.7	5/05/78		
3	7.1	5/17/83		
4	6.4	5/13/61		
5	5.7	5/16/57		
6	5.6	5/29/75		
7	4.7	5/06/78		
8	3.7	5/02/79		
9	3.1	5/01/08,	5/15/57	
11	2.6	5/04/50		
12	2.3	5/09/79,	5/01/54	
14	2.1	5/12/56		
15	1.9	5/08/79		
16	1.7	5/13/67		
17	1.4	5/26/50		
18	1.3	5/12/10,	5/02/88,	5/12/53
21	1.1	5/01/78		
22	1.0	5/11/11,	5/08/64	
24	0.9	5/01/73,	5/05/67	
26	0.8	5/11/66		
27	0.5	5/14/83		
28	0.4	5/13/75,	5/06/67	
30	0.3	5/14/08		

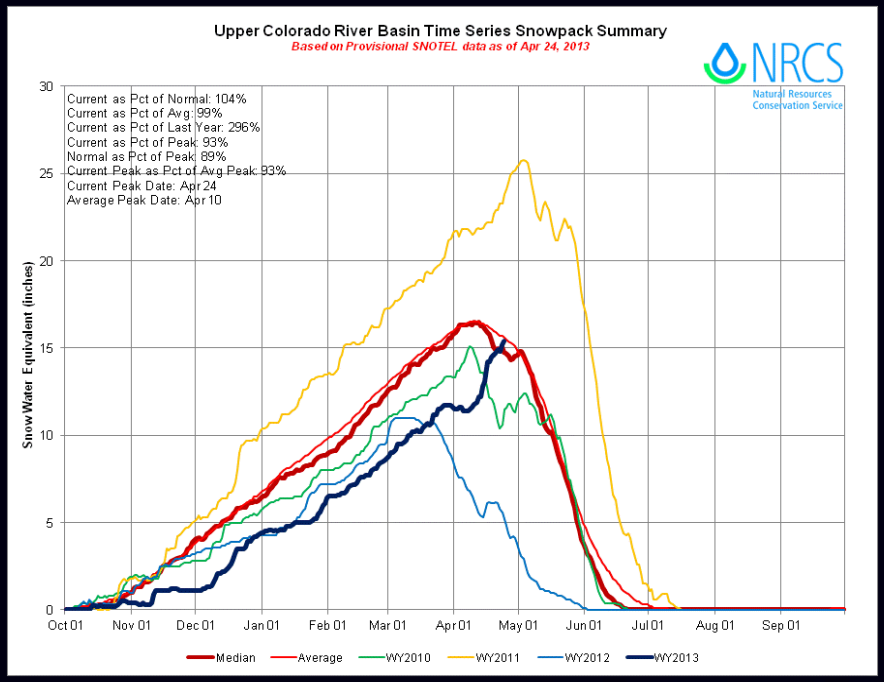

Colorado Snowpack
As of
April 24, 2013



Colorado snowpack as of April 24, 2013 continues to improve across much of the state, particularly across the north and east. The statewide average snowpack is now at 92 percent. Snow water equivalents have inched above their seasonal normals in the northwest basins (102 percent in the Yampa/White River Basins, 103 percent in the Laramie and North Platte River Basins, and 109 percent in the Upper Colorado River Basin). The snowpack has also made positive gains in the South Platte River Basin where it is now 94 percent.







North Central and Northeast Colorado Snowpack

Latest snowpack measurements reveal a marked improvement in snow-water equivalents within the South Platte , Laramie/North Platte and Colorado River basins of north central and northeast Colorado. Given the increase in snowpack in these basins, they still remain below levels normally observed this time of year. The dark blue line represents the snowpack trend for the 2012-2013 winter season.